REPORT DOCUMENTATION PAGE

1a. REPORT SECURITY CLASSIFICATION
UNCLASSIFIED

1b. RESTRICTIVE MARKINGS

2a. SECURITY CLASSIFICATION AUTHORITY

3. DISTRIBUTION/AVAILABILITY OF REPORT
Approved for public release; distribution is unlimited.

2b. DECLASSIFICATION/DOWNGRADING SCHEDULE

4. PERFORMING ORGANIZATION REPORT NUMBER(S)
NOSC TD 1196

5. MONITORING ORGANIZATION REPORT NUMBER(S)

6a. NAME OF PERFORMING ORGANIZATION
Naval Ocean Systems Center

6b. OFFICE SYMBOL (if applicable)
Code 5402

7a. NAME OF MONITORING ORGANIZATION

6c. ADDRESS (City, State and ZIP Code)
San Diego, CA 92152-5000

7b. ADDRESS (City, State and ZIP Code)

8a. NAME OF FUNDING/SPONSORING ORGANIZATION
Chief of Naval Operations

8b. OFFICE SYMBOL (if applicable)
Code OP-098F

9. PROCUREMENT INSTRUMENT IDENTIFICATION NUMBER

8c. ADDRESS (City, State and ZIP Code)
Washington, DC 20350

10. SOURCE OF FUNDING NUMBERS

PROGRAM ELEMENT NO	PROJECT NO.	TASK NO.	AGENCY ACCESSION NO.
63790N	R1952	540-CH42	DN307514

11. TITLE (Include Security Classification)
FRENCH RESEARCH IN ACOUSTICS AND SIGNAL PROCESSING: REPORT ON INTRODUCTORY VISIT

12. PERSONAL AUTHOR(S)
Shelby F. Sullivan, Newell O. Booth, Harper J. Whitehouse

13a. TYPE OF REPORT
Final

13b. TIME COVERED
FROM May 86 TO May 86

14. DATE OF REPORT (Year, Month, Day)
May 1986

15. PAGE COUNT
27

16. SUPPLEMENTARY NOTATION

17. COSATI CODES

FIELD	GROUP	SUB-GROUP

18. SUBJECT TERMS (Continue on reverse if necessary and identify by block number)
France, acoustics, signal processing, organizations, facilities, personalities

19. ABSTRACT (Continue on reverse if necessary and identify by block number)

The initial visit of a new project officer to France to determine the scope and organization of acoustics and signal-processing research is reported. From 6--23 May 1986, eight facilities were visited, including Navy, government university, private university, defense contractor, seismic exploration, and national laboratories working in research applicable to acoustics and signal processing. The tour highlighted some outstanding research in advanced acoustic signal processing. It also provided broad exposure to both the research underway and the French research process itself.

20. DISTRIBUTION/AVAILABILITY OF ABSTRACT
☒ UNCLASSIFIED/UNLIMITED ☐ SAME AS RPT ☐ DTIC USERS

21. ABSTRACT SECURITY CLASSIFICATION
UNCLASSIFIED

22a. NAME OF RESPONSIBLE INDIVIDUAL
S.F. Sullivan

22b. TELEPHONE (Include Area Code)
(619) 553-3060

22c. OFFICE SYMBOL
Code 5402

DD FORM 1473, 84 JAN

83 APR EDITION MAY BE USED UNTIL EXHAUSTED
ALL OTHER EDITIONS ARE OBSOLETE

NOSC TD 1196

NAVAL OCEAN SYSTEMS CENTER San Diego, California 92152-5000

NOSC TD 1196

Technical Document 1196
May 1986

French Research in Acoustics and Signal Processing: Report on Introductory Visit

Conducted Under Auspices of
Data Exchange Agreement Annex F-5617
Chief of Naval Operations (OP-098F)

Shelby F. Sullivan, DEA Project Officer
Newell O. Booth, Acoustics Advisor
Harper J. Whitehouse, Signal Processing Advisor

NAVAL OCEAN SYSTEMS CENTER

San Diego, California 92152-5000

F. M. PESTORIUS, CAPT, USN
Commander

R. M. HILLYER
Technical Director

ADMINISTRATIVE INFORMATION

The visit reported here was funded by and conducted under the auspices of Data Exchange Agreement Annex F-5617 for the Office of the Chief of Naval Operations (OP-098). It is envisioned that this document will be the first in a series of such reports.

Released by
Shelby F. Sullivan
DEA Project Officer

Under authority of
Juergen H. Richter, Head
Ocean and Atmospheric
Sciences Division

RH

CONTENTS

INTRODUCTION

This document reports on the initial visit of a new project officer to France to determine the scope and organization of acoustics and signal-processing research there. During the period 6–23 May 1986, eight facilities were visited, including Navy, government university, private university, defense contractor, seismic exploration, and national laboratories working in research applicable to acoustics and signal processing. The tour was most beneficial in highlighting some outstanding research in advanced acoustic signal processing. It also provided broad exposure to both the research underway and the French research process itself.

The French are world leaders in signal processing theory and algorithm research. This results partially from the strong emphasis on mathematics for all engineering students, as well as the unique leadership of Professor Emeritus H. Mermoz of the National Polytechnical Institute in Grenoble. Current activities of interest in acoustic signal processing include high-resolution bearing (beamforming) and spectral estimation, bispectral analysis for imaging and tomography, and Wigner-Ville analysis of non-stationary signals with application to active sonar.

French scientists now have plans underway to compliment this leadership in signal-processing theory and algorithms with a 128-bit VLSI chip to be developed for a processing element in a systolic array processor. The achievement of this goal will be an impressive advance in the field of undersea acoustics, and should clear the way for even greater accomplishments.

The funding of French research is carried out primarily by two government organizations: Direction de la Recherche et Étude Technique (DRET), a defense research funding agency similar to DARPA, and CNRS (Centre National de la Recherche Scientifique), the French equivalent of the National Science Foundation. CNRS has its own laboratories, and also funds individual researchers at Universities throughout France. The annual budget is 9,000,000,000 French francs. The laboratories of CNRS have 25,000 employees, 10,000 of whom are researchers.

Direction de Constructions Navales (DCN), via STCAN (Service Technique des Constructions et Armes Navales), is the defense organization responsible for the development of military systems, from exploratory development through engineering development. GERDSM (Groupe d'Études et de Recherches de Détection Sous-Marine) is the STCAN laboratory responsible for sonar development. Researchers are given local autonomy, but with direction to work in broad areas. Local autonomy is afforded on what to pursue and how to pursue it. It is a system of great flexibility.

SUMMARY OF VISITS

Each visit is summarized separately in this section.

Service Technique des Constructions et Armes Navales (STCAN), 6 May 1986. Jean-Francois Bonnaud, Chef de la Section "Détection Sous-Marine."

M. Bonnaud is the French DEA (Data Exchange Agreement) Project Officer. After reviewing the itinerary for the visit, Mr. Sullivan requested a modification to allow a visit to Thomson-Sintra in Paris. This modification was accomplished.

M. Bonnaud mentioned that he may pass the DEA Project Officer responsibility to a more technically oriented person at the GERDSM laboratory at LeBrusc.

In a discussion of the goals of the DEA, both M. Bonnaud and Mr. Sullivan expressed their desire to stimulate technology exchange at the working level and to facilitate, where appropriate, research collaboration between individual investigators.

École Supérieure d'Electricité, Université de Paris-Sud, 6 May 1986. Prof. Bernard Picinbono, Directeur, Laboratoire des Signaux et Systèmes (L2S).

The Laboratory of Signals and Systems (L2S) is part of the École Supérieure d'Electricité (ESE), which is associated with the Université de Paris-Sud. ESE is a graduate school in electrical engineering. Students have an undergraduate degree in engineering and are typically associated with or sponsored by CNRS, defense laboratories, defense contractors, or private industry. L2S works in the fields of signal processing, communication systems, and information transmission.

In our visit, we met with the director and two post-doctoral students, who are associated with Navy acoustics and signal-processing research. The more senior, Michel Bouvet, wrote his doctoral thesis modeling the target as a stochastic scatterer with Brownian statistics.[47] Subsequently, he went to Princeton University, where he worked with Prof. W.C. Schwartz of the Information Sciences and Systems Laboratory in the preparation of a joint report on signal detection and normalization in underwater noise modeled as a Gaussian-Gaussian mixture. This work was sponsored by ONR Statistics and Probability Branch, Code 411SP.

The second student, Pierre Bremaud, is just starting his studies with Prof. Picinbono and will be working on temporal signal processing.

Technical briefings were presented covering Picinbono's and Bouvet's current research, which we judged to be of high quality. It is restricted to the temporal, rather than the spatial, processing of signals as part of an informal arrangement originally initiated by Prof. Mermoz, the retired director of the Navy Laboratory at LeBrusc. Spatial processing is primarily the responsibility of the CEPHAG (Centre d'Étude des Phénomènes Aleatoires et Géophysiques), which is associated with the Institut National Polytechnique at Grenoble.

We were given a detailed tour of the Laboratory. The following items were of particular interest.

Acoustic Holography and Tomography: G. Demoment.[47]

This work is done in the microwave frequency regime for high-resolution imaging for medical and nondestructive testing applications. The forward-scattering diffraction tomography techniques may have some application to Navy acoustics by way of detecting perturbations from a submarine in a stationary acoustic field. Preliminary results indicate that it should be feasible to extend this research to reflection tomography, which will have direct application to active sonars. The research does not use the Born approximation, and is an exact solution for diffraction tomography with a changing index of refraction. The work is being experimentally verified in the laboratory.

Range Resolution Improvement by Fast Deconvolution:
G. Demoment and R. Reynaud.[48, 49]

Range resolution improvement in ultrasonic echography is considered as an estimation problem that can be solved by using a new fast minimum variance deconvolution algorithm specially designed for microprocessor-based online processing. By eliminating the square-law detector following the linear receiver, system linearity is preserved and effective use of deconvolution procedures is made possible. This work is relevant to inverse synthetic aperture acoustic imaging.

Thomson-Sintra, Activités Sous-Marine, Cagnes sur Mer, May 12, 1986. Jean-Louis Vernet, Vice President for R&D; Dr. P. Tournois, Consultant; Dr. G. Bienvenue, Research Engineer; and Dr. L. Kopp, Research Engineer.

The Thomson-Sintra Company was formed from the merger of Thomson-CSF and Sintra-Alcatel. The company has facilities in Arcueil, near Paris, in Cagnes-sur-Mer, near Nice, and in Brest. The facility in Brest makes mine-hunting sonars. The Cagnes-sur-Mer facility makes ship sonars for the French Navy and for export.

Thomson-Sintra is currently working with Rockwell International on a proposal to provide a new ship sonar for Australia. They have groups working in signal-processing hardware, signal-processing algorithms, transduction sciences, and array production.

M. Kopp summarized the Bienvenue and Kopp work in high-resolution eigenvector beamforming given at the NATO Advanced Study Institute (ASI) in 1985. This work was done on towed-array data in the 340–640-Hz band in both broadband and narrowband. The work assumes that the array is straight. Bienvenue and Kopp examined and compared several processes in the class of eigenvector beamformers. Significant performance (resolution) improvements were noted. While they have not been directed to further apply the work to an operational sonar, they appear to be working on signal-processing hardware that can better implement the processes.

M. Vernet described and exhibited the Thomson-Sintra signal-processing hardware. A modular 16-bit fixed-point signal-processing element called MANGOUSTE is implemented on multiple boards by using conventional LSI technology. This element is being used as the building block of current developmental systems, achieving 160 megaoperations per second. A new 32-bit processing element called MOUFLON is being developed that is twice the speed of MANGOUSTE in about the same volume. Thomson-Sintra is working toward a 1-gigaop system, which its staff believes is necessary for the effective implementation of real-time eigenvector processing for the sonar systems they envision.

Thomson-Sintra, Activités Sous-Marines, Arcueil, 7 May 1986.

Guy Parent, Director of Technical Services; Jean-Paul Pignon, Studies Engineer; Jean Pradelle, Airborne Products Manager.

M. Pignon described experiments on high-resolution beamforming of vertical array data taken in shallow water in active and passive modes.[5] This study was aimed at improving the performance of a vertical-line-array sonobuoy in coherent background noise in shallow water. The sonobuoy was designed for use in an active sonar system operating at a center frequency of 10.1 kHz. Unfortunately, this work, although well conceived, carefully executed, and showing significant performance improvements, is no longer being supported or implemented. This is the type of work that could form the basis of a joint US-French collaboration.

M. Pradelle described the current inventory and status of French sonobuoys and dipping sonars.[6] Their operational sonobuoy work is similar to work going on in the US and the UK.

Centre National de la Recherche Scientifique (CNRS), Laboratoire de Mécanique et d'Acoustique (LMA), Marseilles, 13 May 1986.

Marc Foti and Robert Bouc, Co-directors.

The Laboratory of Mechanics and Acoustics[10] (LMA) is a French national laboratory administered by CNRS, the French equivalent of the National Science Foundation. It is affiliated with the University of Aix-Marseilles II, which offers a specialized degree in acoustics.[9] LMA has researchers using its facilities who are associated with other universities both in France and the US. While CNRS is the primary sponsor of research, occasional projects are supported by DRET, the French equivalent of DARPA, and GERDSM, the Navy Laboratory in LeBrusc.

We were presented an overview of the laboratory, which works in the following areas.

Active Absorption.[8]

Alain Roure and Bernard Nayroles.

Active sound absorption is a procedure of attenuation that consists of superimposing an antiphased noise on an unwanted one to cancel the field in the zone that is to be protected. This technology is suitable for application to submarine quieting and airborne noise reduction. Demonstrations were provided of active noise reduction inside a headphone/helmet and in air-conditioning ducts.

Ultrasonics.[53, 55]

Jean-Pierre Sessarego.

This group is working in propagation in dispersive media; e.g., bubbling water and laminated composites. This combined theoretical and experimental work has application to noise and vibration isolation in sonars and ship quieting with bubble screens.

Underwater Propagation.

Claude Gazanhes, J. L. Garnier, and Paul Filippi.

The emphasis is on normal-mode acoustic propagation in a fast bottom channel. Normal-mode theory for shallow-water propagation is used to develop a method permitting the filtering or excitation of a single mode by means of a vertical array of transducers. This method improves the reception of a transmitted signal and resolves the multipath transit times. The work includes scale-model experiments in the laboratory.

Acoustic Imaging.

Work in acoustic imaging is centered on sampled analog techniques to achieve dynamic focusing, electronic scanning, and multiple beamforming.

Acoustical Tomography.[52]

J. P. Sessarego and Jean Pierre Lefevre.

This group is experimenting with both transmission and backscattering tomography, as well as acoustic impedance tomography.

Target Identification.[54]

C. Gazanhes and J. P. Sessarego.

Transfer functions and impulse responses of rigid and elastic shapes are investigated over a wide range of the size/wavelength parameter. These functions are calculated initially from an analytical model and then verified experimentally from backscattering measurements. Although all of the work described was done at ultrasonic frequencies, it has direct application, by means of scaling, to ASW applications.

Environmental Acoustics and Perception.

Bertram Scharfe, exchange scientist from Northeastern University, Boston, MA.

This group is currently working on a task from STCAN in auditory perception as it relates to sonar operator selection and performance evaluation. The group's French leader is currently at Northeastern University.

Digital Sound Synthesis.

Jean-Claude Risset.

This demonstration illustrated that psychoacoustics is as important to sound synthesis as is the faithful reproduction of measurable spectra. A task to develop a signal synthesizer to train sonar operators is being sponsored by GERDSM (see below.)

Groupe d'Études et de Recherches de Détection Sous-Marine (GERDSM), Le Brusc, 14-16 May 1986.

ICA M. LeFaudeux, Commanding Officer, and Prof. P.Y. Arques, Applied Research Technical Director.

GERDSM is a French Navy Laboratory specializing in submarine detection research and development. Administratively, it is part of DCN, Toulon. A sister laboratory in Brest specializes in air systems, minehunting sonars, and torpedoes. GERDSM has 1200 employees, of which 400 are engineers and scientists.

Our tour started with a visit to the Acoustic Test Facility at the lake complex near Castillon. The facility is similar to Lake Pend Oreille, Idaho, in that it can test heavy sonars in noise conditions less than those of sea state zero.[14] One-tenth-scale model testing of the current French SSBN was being conducted for radiated noise and target strength. Developmental tests were also being conducted on a scale model of the next-generation submarine spherical receiving array. This recently refurbished, modern facility demonstrates the French commitment to sonar and submarine R&D.

GERDSM has participated with the NATO SACLANT research center in joint exercises in the Mediterranean involving active towed-array sonar experiments. GERDSM officials indicated that a French submarine was used as a target, along with a French surface-towed receiving array. Both SACLANT and GERDSM provided sources.

GERDSM has three major divisions, Operational Systems, Exploratory Development, and Applied Research. Summaries of relevant work were given from the Exploratory Development Division and the Applied Research Division. Work was described in the following major areas.

Arrays (Antennas).

Dr. Didier Husson.

Active and passive tactical towed arrays and passive submarine spherical arrays.

1. Passive spherical submarine bow array.[12, 13] An analytic solution of a layered sphere was described, and was complemented with computer animation of the modes and experimental confirmation from Lake Castillon experiments of the spectral response. This work built on the theoretical and scale-model work done at CNRS, Marseilles. The researcher, Didier Husson, obtained his PhD from Stanford under Prof. Kino, specializing in acoustic imaging for nondestructive testing.

2. Multiple planar submarine hull arrays. An extension of work by NSRDC in wide-aperture array baffling was presented, along with analysis and the results of scale-model testing in the LeBrusc Pressure Tank.

3. Passive towed array. This presentation illustrated elements and multiplexing systems that were being designed and tested.

4. Active source tow body. Activate towed array in 500- to 1000-Hz range, with two planar source arrays in the array tow body. The concept achieves source directivity and removes left–right ambiguity. A novel design of the transduction element illustrated the tight coupling of experiment and theory, which yielded a small, efficient, broadband, high-power element. A flexible piston head was coupled to a ceramic stack, with multiple electrical inputs and a re-entrant tailmass, forming a half-wavelength mass-loaded resonant element, commonly referred to as a tonpliz transducer. The amplitudes and phases of the multiple inputs are controlled to generate a broadband spherical wave.

5. Hydrophones. Work on piezoelectric polymer hydrophones, including polyvinylfluoride thick film, is being pursued. Also reported was an optical hydrophone for an all-optical towed array.

Environment.

M. Ancey.

A simple, effective fleet acoustic prediction system, which is implemented on a Hewlett-Packard desktop computer, was implemented. State-of-the-art acoustic modeling techniques, including parabolic approximation and bottom interaction, are used in

research and performance analysis. While the work is of high quality, no techniques were apparent that are not encountered in the US. As would be expected, GERDSM has a significant database of environmental information on the acoustic oceanography of the Mediterranean Sea and waters near France.

Signal and Noise.

Dr. M. Bouvet.

Dr. Bouvet, who briefed us at the Laboratory of Signals and Systems, will return to GERDSM to further apply the statistical noise-modeling techniques. Other more conventional work is also proceeding, specifically ship-radiated noise measurement and reduction.

Signal and Information Processing.

J. P. LeCadre.[52]

An in-depth exploratory development program in high-resolution spatial processing is being executed, with particular emphasis on uniformly spaced towed arrays. A cross section of matrix inversion and eigenvector methods is being thoroughly tested with recorded data. Preliminary results indicate a factor of 2-3 improvement in resolution, with eigenvector techniques providing automatic normalization. Emphasis is on processing sectors by using beam data rather than element or subarray data.

The GERDSM laboratory is working with and sponsoring research at a broad group of university and government laboratories. GERDSM personnel do an outstanding job of maintaining current awareness of theoretical developments, including those sponsored by DRET, and are experimentally evaluating advanced theory and research. Most of their research has yet to be applied to systems. The French Navy mission appears to be focused on waters adjacent to France. Like similar investigators in the US, GERDSM personnel are quite able to implement systems for platforms, but seem to have a limited conception of how groups of platforms would be used in naval warfare.

Groupe d'Études "Signaux et Systèmes" (GESSY), La Garde, 16 May 1986.

Prof. Guy Leberton, Château St-Michel.

Prof. Leberton invited Mr. Whitehouse for a visit to the GESSY laboratory, which is affiliated with the Université de

Toulon et du Var. The major role of this laboratory, funded in part by DRET and DCN, is analog and digital signal-processing research. Prof. Leberton is currently working on advanced signal processing, including the application of Wigner-Ville analysis. Two programs of particular importance to this DEA were described. The first, funded by DRET, is on optical correlation applied to sonar signals[53] and the second, supported by DCN, is on optical spectrum analysis of acoustic signals.[54]

Societé Nationale ELF Aquitaine, Pau, 20 May 1986.

Dr. Eric Bazelaire.

Societé Nationale ELF Aquitaine (SNEA) is a French petroleum company that is recognized worldwide for its exploration and geophysical techniques. The major facilities are located in Paris and Pau. We visited Dr. Eric DeBazelaire in Pau, who described geophysical signal-processing techniques used by SNEA in its oil exploration business. DeBazalaire and B. Boashash were the first people to apply the theory of Wigner-Ville analysis, which is a method of nonstationary signal analysis analogous to the Fourier transform (which itself is applicable only for stationary signals). More specifically, Wigner-Ville is a bilinear nonstationary extension of Fourier analysis. This type of analysis allowed DeBazelaire and Boashash to demonstrate that propagation losses in sedimentary layers in the 10- to 150-Hz region result from scattering rather than from absorption. SNEA's work in signal processing is representative of French industry's appreciation of advanced techniques of signal processing developed in the universities.

Although ocean seismic exploration is fundamentally different from active sonar operations, there are many similarities worth considering. The most important is that the frequency of insonification covers the band from 10 to 150 Hz, with extended application to 300 Hz. Long (3-km) seismic streamers (towed arrays) are routinely employed as receivers, although explosive devices are normally used as the active source. A novel controlled source was described, equivalent to a ship-mounted vibrosise, which was capable of providing controlled linear frequency modulation over the acoustic bandwidth. Special precautions are taken to avoid laterally propagating acoustic insonification in shallow water.

SNEA has demonstrated active sonar to 25-km depth, with the prime loss being scattering rather than absorption. Seismic information from the North Sea indicates, for example, that propagation in this shallow-water region in the top layers of sediment may provide the opportunity for effective long-range active sonar.

Institute for Chemistry and Physics in Industry (ICPI), Lyon Catholic University, 22 May 1986.

P. Flandrin and M. Zakharia.

Dr. Flandrin's specialty is time-frequency analysis, with particular emphasis on Wigner-Ville representations. M. Zakharia is specializing in high-frequency active sonars for navigation and national fisheries activities. Working in support of Prof. Escudié, Dr. Flandrin is doing primarily theoretical developments, with some educational responsibilities at the university. He is supported by a staff of about five student researchers working on various experimental verifications and hardware realizations based on his work. His support is primarily from CNRS.

Technically, Dr. Flandrin's main contribution is the extension of WV analysis to stochastic processes estimated from a single realization of the process. This work is of particular interest, since the question of positivity of the WV distribution can be shown to be a direct consequence of the signal representation for many stochastic models. The work is sufficiently mature to be coupled with Bouvet's theoretical work on random target modeling from L2S. This combined work would be of great interest in submarine target strength estimation and active-sonar signal processing. There is no indication that the French are pursuing this.

Zakharias is studying a Wigner-Ville interpretation of the bionic sonar work of Dr. R. Altes in the United States. It is premature to determine whether this work will result in concepts significantly different from those which have been investigated by the US Navy.

An experimental program is in process for the identification of noise sources on moving vehicles such as trains and automobiles. This technique may have some generalization at high signal-to-noise ratio in underwater noise measurement programs.

Centre d'Étude des Phénomènes Aleatoires et Géophysiques (CEPHAG), Institut National Polytechnique, Université de Grenoble, 23 May 1986.

Prof. J. L. Lacoume, Director.

CEPHAG is a center associated with the Institut National Polytechnique in Saint-Martin-d'Heres, a suburb of Grenoble. As at L2S, students have completed an undergraduate degree and are often sponsored by CNRS, DRET, industrial, or defense laboratories.

The function of CEPHAG is to concentrate its efforts on the development of methods and techniques for signal processing in conjunction with specialists in the different areas of application: submarine acoustics with the French Navy, geophysics with EISCAT, and instrumentation with the industrial sector. Reference 43 is a bibliography of CEPHAG publications covering the period 1983–85.

Submarine Acoustic Array Processing.

Acoustic propagation is viewed as a transfer function, with deterministic and stochastic portions used to examine communications over random dispersive channels.[55, 56] The effects of scattering on spatial and temporal processing are examined theoretically and experimentally. High-resolution beamforming results from low-frequency towed linear arrays were presented.[57]

Spectral and Cross-Spectral Analysis.

A theoretical study of the statistical properties of autoregressive estimators, based on a least-squares method, was described. The primary result was that the least-squares estimator of the autoregressive parameters is a likelihood estimator. These results were for the general case of a complex autoregressive process of order M.[58]

Signal-Processing Implementations.

A reconfigurable signal-processing computer, which is being used for student experiments and limited research, was demonstrated. It was developed jointly between CEPHAG and the CNRS computer architecture group of the TIM3 microelectronics laboratory, Grenoble, which specializes in computer architecture, circuit design, and prototype manufacture.

TIM3 is actively working in the development of systolic array processors following approaches similar to those of J. McWhirter at the Royal Signals Research Establishment (RSRE) Mulburn, UK; that is, bit-level systolic arrays using bit serial arithmetic.[44] A particularly interesting application of these techniques is in a VLSI design for a new systolic processing element. Traditionally, a choice is made between high-performance, fixed-word-length computation and the more flexible but lower-performance floating-point computation. This tradeoff results from the short word lengths of conventional multiplier accumulators used for the implementation of most systolic arrays, and from the complexity associated with floating-point additions. The CEPHAG/TIM3 approach is refreshing in that workers there have overcome the

limitation of the floating-point adder by using a fixed-point word 128 bits long. The word possesses so much dynamic range that it has the performance of a floating computation and the simplicity of a fixed-point design, but suffers only a small reduction in performance over shorter-word-length implementations. To obtain full computational generality (i.e., addition, subtraction, multiplication, division, SQRT, and SQRT sum squares), an improved implementation of the well-known CORDIC algorithm is used. This chip is being developed in CMOS technology.

A major contribution of Prof. LaCoume has been the creation within the Groupe de Recherche et d'Étude de Traitement du Signal et des Images (GRETSI) organization of a new journal called "Traitement du Signal." This journal, which is primarily directed to a francophone audience but has an English technical summary, is rapidly becoming the premier journal for signal-processing research supported by CNRS and DRET. "Traitement du Signal" and the GRETSI biennial colloquia on signal processing are the major publications of record for French signal-processing research.

SACLANT Center, La Spezia, Italy.

Mr. Whitehouse visited SACLANT Center, in part to determine the scope of French participation in SACLANT research. He met with Dr. Petersen from NUSC, who has been at the center 15 months and is working in Division 20 on active sonar.

While the French Government's involvement in NATO is minimal, French acoustics has made significant contributions to SACLANT programs in low-frequency active sonar and target strength measurement. The French submarine that was used as a target in the tests described in the GERDSM section was a modern non-nuclear vessel whose skipper went out of his way to support the technical objectives of the experiment. A French surface-towed array was used for the high-resolution beamforming experiments of this series, along with sources provided by both GERDSM and SACLANT.

US POINTS OF CONTACT

DATA EXCHANGE AGREEMENT PROJECT OFFICER

Mr. Shelby F. Sullivan, Head, Advanced Concepts Office, Code 5402, Naval Ocean Systems Center, San Diego, CA 92152-5000, Tel (619) 225-6805.

OFFICE OF DEFENSE COOPERATION, PARIS

CDR Allan Junker, USN, Office of Defense Cooperation (ODC), American Embassy, 2 rue St. Florentin, 75001 Paris, France, Tel 42.96.12.02 X-2486.

FRENCH POINTS OF CONTACT

DATA EXCHANGE AGREEMENT PROJECT OFFICER

M. Jean-Francois Bonnaud, Ingenieur en Chef de l'Armement, Chef de la Section "Détection Sous-Marine," Ministère de la Défense, DCN, Service Technique des Construction et Armes Navales, STCAN, 8 bd. Victor, 75732 Paris, Tel 45.54.92.11-Poste 31266.

ÉCOLE SUPÉRIEURE D'ELECTRICITÉ, UNIVERSITÉ DE PARIS-SUD

Prof. Bernard Picinbono, Directeur, Laboratoire des Signaux et Systèmes (L2S), École Supérieure d'Electricité, Plateau du Moulon, 91190 Gif Sur Yvette, Tel 941.80.40.

THOMSON-SINTRA, Arcueil, near Paris

M. Guy Parent, Director of Technical Services, Thomson-Sintra, Activités Sous-Marines, 1 ave. Aristide-Briand, 94117 Arcueil Cedex, France, Tel 42.53.15.80.

THOMSON-SINTRA, Cagnes-sur-Mer, near Nice

M. Jean-Louis Vernet, Technical Director, Thomson-Sintra, Activités Sous-Marines, Chemin des Travails, BP 53, 06801 Cagnes-sur-Mer Cedex, France, Tel 93.20.01.40.

CENTRE NATIONAL DE LA RECHERCHE SCIENTIFIQUE, Laboratoire de Mécanique et d'Acoustique (LMA), Marseilles.

M. M. Foti, Chargé des Relations Extérieures du LMA, Centre National de la Recherche Scientifique, Laboratoire de Mécanique et d'Acoustique, BP 71, 13277 Marseilles Cedex 9, 31 chemin Joseph-Alguier, France, Tel 91.22.40.00.

GROUPE D'ÉTUDES ET DE RECHERCHES DE DÉTECTION SOUS-MARINE (GERDSM), Le Brusc, near Toulon.

ICA M. LeFaudeux, Commanding Officer, and Prof. P.Y. Arques, Applied Research Technical Director, Groupe d'Études et de Recherches de Détection Sous-Marine, (GERDSM), Le Brusc, 83140 Six-Fours-Les-Plages, France, Tel 94.74.90.00.

GROUPE D'ÉTUDES "SIGNAUX ET SYSTÈMES" (GESSY), La Garde, near Toulon.

M. G. Lebreton, Groupe d'Études "Signaux et Systèmes" (GESSY), Château St-Michel, 83130 La Garde, France.

SOCIETÉ NATIONALE ELF AQUITAINE, Pau.

M. Eric De Bazelaire, Departement de Recherche Sismique, Societé Nationale ELF Aquitaine, 26 ave. des Lilas, 64018 Pau Cedex, France, Tel 33.(59)83.64.43.

INSTITUTE FOR CHEMISTRY AND PHYSICS IN INDUSTRY (ICPI), Lyon.

M. Patrick Flandrin, Laboratoire de Traitement du Signal, LA 346 b, CNRS, ICPI, 25 rue du Plat, 69288 Lyon Cedex, France, Tel 72.32.50.67.

CENTRE D'ÉTUDE DES PHÉNOMÈNES ALEATOIRES ET GÉOPHYSIQUES (CEPHAG), Grenoble.

Prof. J. L. Lacoume, Technical Director, ENSIEG, BP 46, 38402 Saint-Martin-d'Heres Cedex, France, Tel 76.44.82.45.

BIBLIOGRAPHY

Entries 1 through 44 are available from Mr. S. F. Sullivan, Code 5402, NOSC, San Diego, CA 92152-5000.

1. Laboratoire des Signaux et Systemes, "Description and Bibliography," 1984.

2. Mohammad-Djafari, Ali, and Guy Demoment. "Maximum Entropy Diffraction Tomography," to be published in Proceedings IEEE ICASSP 86, Tokyo, Apr 7-11, 1986.

3. Saint-Felix, Didier, Du-Xue-Cheng, and Guy Demoment. "Image Deconvolution Using 2-D Non-Causal Fast Kalman Filters," to be published in Proceedings IEEE ICASSP 86, Tokyo, Apr 7-11, 1986.

4. Houacine, Amrane, and Guy Demoment. "Chandrasekhar Adaptive Regularizer for Adaptive Filtering," to be published in Proceedings IEEE ICASSP 86, Tokyo, Apr 7-11, 1986.

5. Pignon, J. P., and J. J. Rihouey. "Adaptive Active Sonar Reception in Shallow Water Using Vertical Array Outputs and Covariance Matrix Eigen values: Experimental Results."

6. Thomson-Sintra. "HS 12 Panoramic Sonar for ASW Helicopter," Activités Sous-Marines.

7. Fillippi, Paul J. T., and Dominique Habault. "Sound Radiation by a Baffled Cylindrical Shell: Boundary Elements Method and Fourier Series Solution," International Conference: Boundary Elements, 14-17 Oct 1986, Tsinghua University, China.

8. Roure, A. "Self-Adaptive Broadband Active Sound Control System," Journal of Sound and Vibration (1985) 101(3), 429-441.

9. Filippi, B. "Diplome d'Études Approfondies d'Acoustique," Laboratoire de Mécanique et d'Acoustique (1986-1987).

10. "Rapport D'Activité," Centre National De La Recherche Scientifique, Laboratoire de Mécanique et d'Acoustique (1983-1984).

11. Lecadre, J.P. "High Resolution Methods for Array Processing," 16 May 1986.

12. Husson, Didier. "Diffraction d'Une Onde Acoustique Plane par une Sphére Elastique," Traitement Du Signal, Vol. 2, No. 5, Sept 1985.

13. Husson, Didier. "Resonances d'Une Sphère Elastique Multicouche."

14. GERDSM, "Noise Data for Castillon Sonar Test Facility," 15 May 1986.

15. "Geophysical Activity," Direction Exploration, Societé Nationale ELF Aquitaine.

16. "Exploration," Societé Nationale ELF Aquitaine.

17. "Research Development Innovation," Societé Nationale ELF Aquitaine.

18. Institut de Chimie et Physique Industrielles de Lyon, 1986.

19. "Bibliography," Laboratoire de Traitement du Signal, I.C.P.I. Lyon.

20. Robert, Yves, and Maurice Tchuente. "An Efficient Systolic Array for the ID Recursive Convolution Problem." Journal of VLSI and Computer Systems, Vol. 1, No. 4.

21. Zakharia, M. "Problèmes Inverses en Sonar de Peche: Possibilités et Limitations," Extrait de la Revue du CETHEDEC 20 Année, 3 Trimestre 1983, No. 76.

22. Zakharia, M., and others. "Improvement of Underwater Acoustic Localization by Coherent Processing." I.C.P.I. Lyon.

23. Zakharia, M. "Reflexions sur la Mesure de la Réponse Spatio-Frequentielle d'Une Cible Sonar," Colloque Jesa, Lyon, Jun 1986.

24. Zakharia, M. "Statistical Time-Varying Look at Sonar Target Identification," Workshop on ASSP, IEEE Academia Sinica, Pekin, Apr 1986.

25. Bouhier, M. E., and M. E. Zakharia. "Noise Influence on the Accuracy of Source Localising, Comparison of Various Receivers With an Imposed Architecture," ICASSP 86, Tokyo, Japan.

26. Flandrin, Patrick, Wolfgang Martin, and Manell Zakharia, "On a Hardware Implementation of the Wigner-Ville Transform," Digital Signal Processing-84.

27. Bouhier, M. E., and M. Zakharia. "Comparison de Diverses Chaines de Detection en Vue d'Applications Operationnelles," Dixième Colloque sur le Traitement du Signal et ses Applications, 24 May 1985.

28. Sessarego, J. P., C. Gazanhes, and M. Zakharia. "Reponse Acoustique de Cibles et Formation d'Echos," International Conference on Air-Borne Animal Sonar Systems, Colloque CNRS, Feb 1985, to be published in Acustica.

29. Zakharia, M. "Sonar Evaluation in Natural Environment," International Conference on Air-Borne Animal Sonar Systems, Colloque CNRS, Feb 1985, to be published in Acustica.

30. Zakharia, M., and J.P. Sessarego. "Sonar Seeing," International Conference on Air-Borne Animal Sonar Systems, Colloque CNRS, Feb 1985, to be published in Acustica.

31. Zakharia, M. E., "Relationship Between Paley-Wiener Theorem and the Stationary Phase Method?" ICASSP-84, San Diego, CA.

32. Zakharia, M. E., O. Bachet, and J.P. Corgiatti. "Coherent Processing in Underwater Acoustic Localising," International Conference on Computers, Systems & Signal Processing, Bangalore, India, 10-12 Dec 19.

33. Zakharia, M., and J.M. Pey. "Détection et Comptage de Poissons par Sonar Haute Fréquence. Possibilités de Reconnaissance des Espèces et d'Estimation de la Taille," Neuvième Colloque sur le Traitement du Signal et ses Applications, Nice, France, 20 May 83.

34. Zakharia, M., and J.P. Sessarego. "Sonar Target Classification Using a Coherent Echo Processing," 1982 IEEE Conference 3-5 May 19.

35. Escudié, B., J. P. Sessarego, and M. Zakharia. "Target Identification by Bats: Shape and Size of Preys Described by the Sonar Echoes," First European Symposium on Bat Research, 16-20 May 19.

36. Zakharia, M., B. Escudié, and J.P. Sessarego. "Analyse Conjointe en Temps et Fréquence Adaptée a des Signaux Èchos et Classification de Cibles en Sonar Actif: Application a la Reconnaissance de Poissons par Sonar Haute Fréquence," 5 Jun 19.

37. Flandrin, Patrick, and Bernard Escudié. "Principle and Application of Time-Frequency Analysis by Means of the Wigner-Ville Transform," Traitement Du Signal, Vol. 2, No. 2, 1985.

38. Martin, Wolfgang, and Patrick Flandrin. "Wigner-Ville Spectral Analysis of Nonstationary Processes," IEEE Transactions on Acoustics, Speech, and Signal Processing, Vol ASSP-33., No. 6, Dec 1985.

39. Flandrin, Patrick. "On Detection-Estimation Procedures in the Time-Frequency Plane," IEEE ICASSP 86, Tokyo, CH2243-4/86/0000-2331.

40. Flandrin, P. "Some Features of Time-Frequency Representations of Multicomponent Signals," ICASSP 84 Proceedings, Vol. 3 of 3, 19-21 Mar 1984.

41. Flandrin, Patrick, and Bernard Escudié. "Theory of Signals—On the Localization of Joint Representations in the Time-Frequency Plane," Oct 1982.

42. Comon, P. and Y. Robert. "A Systolic Array for Computing BA^{-1}," Institut National Polytechnique, Rapport CEPHAG No. 8/86, Grenoble, 15 Jan 1986.

43. Rapport D'Activité 1983/1985, CEPHAG.

44. Activity Report 1985, IMAG/TIM3 Laboratory, Computer Architecture Group.

45. Leberton, G., "Representation Temps-Fréquence: Definition d'une Densité Energétique et Realisation Physique de Filtres Bidimensionnels," Dixième Colloque sur le Traitement du Signal et ses Applications. Nice, 1985. Sponsored by GRETSI.

46. Picinbono, B., M. Bouvet, and T. Kadota. "Détection d'un Signal Déterministe Aprés Réflexions Multiples," Colloque GRETSI, Nice, 1983, pp 99-104.

47. Herment, A., G. Demoment, and P. Peronneau. "Echographic Signal Processing," Proceedings UBIOMED 6, Ultrasound in Biology and Medicine, Jablona, Varsovie, 19-24 Sep 1983.

48. Demoment, G., R. Reynaud, and A. Segalen. "Estimation Sous-Optimale Rapide Pour la Deconvolution en Temps Réel," Colloque GRETSI, Nice, 1983, pp 205-210.

49. Ultrasonic Imaging, Vol. 6., pp 435-451, 1984.

50. Gazanhes, C., J.L. Garnier, and J.P. Sessarego. "Computer Simulation of Spatial Filtering of Modes by Vertical Array Steering and Double Symmetrical Angles of Sight in Shallow Water Propagation," Journal of Sound and Vibration, 94, No. 2, 1984.

51. Gazanhes, C., J.L. Garnier, and J.P. Sessarego. "Signal Processing for Multimodal Transmission in Shallow Water Acoustic Communication," Signal Processing, 6, No. 3, 1984.

52. LeCadre, J. P., "Estimation au Sens du Maximum de Vraisemblance d'un Modèle Autoregressif. Application au Traitement Spatial d'Antennes," Traitement du Signal, V2(4), p 291, 1985.

53. Leberton, G., "Correlation Optique Appliquée aux Signaux Sonar," GESSY Report No. 5-81, 3 April 1981.

54. Leberton, G. "Analyse Spectrale Optique de Signaux Acoustiques," GESSY Report No. 84/1, 1 Feb 1984.

55. Jourdain G., and H. Cherifi. "Performances et Robustesse d'un Récepteur de Rayleigh en Présence de Milieu Dispersif," GRETSI Colloquium, Nice, May 1985.

56. Faure, B., J.Y. Jourdain, and M.A. Pallas. "Analyse de Signaux Propagés dans la Mer. Propagation Horizontale," Journée Océanographie et Défense, Brest, 4 March 1985.

57. Munier, J., and G.Y. Delisle. "De l'Analyse Spatiales Continue a l'Analyse Paramétrique," GRETSI Colloquium, Nice, 1985.

58. Martin, N., and J.L. Lacoume. "Étude des Proprietés Statistiques des Estimateurs Autoregressifs," GRETSI Colloquium, Nice, 1985.